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ATTACHMENT 2

January 26, 1998

White Paper Supporting Petition Under Section 706 of the Telecommunications Act of 1996

I. The Internet is Congested

The Internet is probably the most important development in mass communications of our times.[1] The Internet promises to become a major driver of economic growth in the United States[2] and around the globe.[3] The Internet had 19 million host computers in July 1997, over 20 times the number five years earlier.[4] The number of Internet Service Providers (ISPs) in the United States doubled in 1995 alone.[5] The Internet serves an estimated 56 million U.S. subscribers today, double what it served a year ago.[6]

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[1] The United States Internet Providers Association calls the Internet "one of the most desired new mass communications mediums [sic] of the United States." Comments of the United States Internet Providers Association at 3, Usage of the Public Switched Network by Information Service and Internet Access Providers, CC Dkt. No. 96-263 (F.C.C. filed Mar. 24, 1997).

[2] *Id.* at i ("The explosion of the ISP industry and the Internet is resulting in significant new economic opportunities for businesses and a new mass communications medium for consumers."); *Id.* at 3-4 ("No doubt, as one of the fastest growing communications media in the world, the Internet will be a driving force behind economic growth in the United States into the 21st century.").

[3] K. Werbach, Office of Plans and Policy, FCC, OPP Working Paper 29, *Digital Tornado: The Internet and Telecommunications Policy* at iii (Mar. 1997).

[4] Network Wizards, *Internet Domain Name Survey*, July 1997, http://www.nw.com/zone/WWW/report.html. A host used to be a single machine on the Internet. Today, a single computer may host multiple systems (with multiple domain names and Web addresses).

[5] K. Werbach, Office of Plans and Policy, FCC, OPP Working Paper 29, *Digital Tornado: The Internet and Telecommunications Policy* at 21 (Mar. 1997).

[6] IntelliQuest Press Release, *Latest IntelliQuest Survey Reports 56 Million American Adults Access the Internet/Online Services*, Nov. 18, 1997, http://www.intelliquest.com/about/release37.htm; President Bill Clinton, Remarks by the President to the People of Knoxville (Oct. 10, 1996), http://www.pub.whitehouse.gov/white-house-publications/1996/10/1996-10-10-president-and-vp-remarks-in-knoxville-tn.text (claiming 25 million U.S. Internet users).

In the Telecommunications Act of 1996, Congress recognized the importance of the Internet and similar new technologies. Section 706 of the 1996 Act requires the FCC and the state commissions to "encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans (including, in particular, elementary and secondary schools and classrooms)."[7] "Advanced telecommunication capability" is then defined in section 706(c) as "high-speed, switched, broadband telecommunications capability that enables users to originate and receive high-quality voice, data, graphics, and video telecommunications." Former FCC Chairman Reed Hundt has expressed his goals for what the "advanced telecommunications capability" should comprise: "In terms of architecture, we need a high-speed, congestion-free, always reliable, friction-free, packet switched, big bandwidth, data friendly network that is universally available, competitively priced, and capable of driving our economy to new heights. We need a data network that can easily carry voice, instead of what we have today, a voice network struggling to carry data."[8]

The Internet of today, even of the next year or two, is not this network. It is not available to all Americans, and will not be for the foreseeable future, if the major Internet backbone providers are not jolted into action. Despite the efforts of the local telephone companies to offer better and faster ways for consumers and schools to access it, the Internet is still slow, clogged, and congested, offering download speeds barely suitable for simply text and graphics, and wholly inadequate for audio, video, and interactive technologies.

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[7] Telecommunications Act of 1996 § 706 (codified as a note following 47 U.S.C. § 157).

[8] Reed Hundt, Chairman, FCC, *The Internet: From Here to Ubiquity*, speech before The Institute of Electrical and Electronics Engineers, The Symposium on Hot Chips, Aug. 26, 1997.

Demand for Internet bandwidth is rising rapidly. John Sidgmore, Vice Chairman of WorldCom and CEO of UUNet, has stated that demand for bandwidth is doubling every 3½ months.[9] But the companies building the Internet backbones are not able, technically and financially, to keep up with demand, and are not willing to supply anyone but large businesses with sufficient bandwidth. Backbone providers have almost exclusively focused their efforts on expanding the capacity of their existing routes between the top 30 major cities; expanding outwards to the next 30 cities, or the next 50, or the next 100, probably is beyond their capabilities.

While it moves information of any kind, including voice, graphics, and video, traffic on the Internet is transmitted as data packets, through packet-switched networks. Voice traffic ordinarily is circuit-switched. Internet Protocol routers do not hold circuits for individual transmissions, but rather disassemble messages into small pieces of information " packets" and send them along a variety of routes until they reach their destination, where they are assembled into the original message. This takes much better advantage of the "bursty" nature of data transmissions, by allowing circuits to be shared among numerous transmissions.[10] And data networks carrying graphics, video, and limitless amounts of communication between computers will ultimately require far more capacity " bandwidth" than the existing networks that support voice conversations between humans.

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[9] M. MacLachlan, *WorldCom Makes Megadeals to Develop Network Infrastructure*, Internet Week, Oct. 6, 1997.

[10] Different vendors even manufacture circuit switches and packet switches. The dominant switch vendors are old-line telephone equipment suppliers Lucent Technologies (formerly a division of AT&T) and Northern Telecom (a division of Bell Canada); the dominant backbone router vendor is Cisco Systems, a Silicon Valley upstart founded in 1984.

So today's voice network is plainly <u>not</u> the "advanced capability" network contemplated by Congress in Section 706. As the former FCC chairman noted, "Today's network is not the new species of communications network that I'm hoping for and that the country needs."[11]

The network of tomorrow likely will be based on the model currently being built to connect major universities, known as Internet2. Internet2 will "establish an efficient, high-speed network among participating universities and . . . design applications to take advantage of the network."[12] The core of this model is the "gigaPOP," a massive, high-speed interconnection point providing end users convenient access to the network. In Internet2, the gigaPOPs will be interconnected initially via 45 Megabit-per-second T-3 links, but will be upgraded to 2.4 gigabit-per-second links in the near future. Internet2 has been designed to provide access to 110 universities throughout the U.S. using only 20 to 30 of these gigaPOPs.[13]

This is the kind of "advanced telecommunications capability" envisioned by Congress, the FCC, and Bell Atlantic: a highly efficient, incredibly high-speed network free of the congestion and delays so common today. Bell Atlantic has the technical skills, financial strength, and consumer focus necessary to make this type of network more widely available. The network Bell Atlantic wants to build will be a drastically improved version of the Internet, able to carry traditional World Wide Web traffic, full-motion video, and any other kinds of data available at 10 to 100 times the speed current networks struggle to achieve. Unfortunately, current regulations bar or deter Bell Atlantic from making this network a reality.

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[11] Reed Hundt, Chairman, FCC, *The Internet: From Here to Ubiquity*, speech before The Institute of Electrical and Electronics Engineers, The Symposium on Hot Chips, Aug. 26, 1997.

[12] *Group Formed for Faster Internet*, AP Online, Oct. 8, 1997 (quoting a University of Michigan spokesman).

II. Choke Points in the Internet

Today's network is indeed "struggling" to carry data. To the frustration of millions of users, the speed and quality of data service is far from satisfactory: the Internet frequently "chokes."[14] The plans of one important group of users, university researchers, to build their own replacement network are one indication of this. The federal government is also working to deploy the Next Generation Internet, which will link government agencies to researchers through a similarly new, high-speed network.[15] Industry analysts likewise agree that the Internet backbones are very congested, and offer unsatisfactory performance.[16]

Contrary to popular perception, the main choke points in the existing Internet lie in the upper reaches of the network. There are too few builders of, and too little investment in, the Internet "backbone." Furthermore, with appropriate regulatory relief, the local telephone companies will deploy advanced, new, local access technologies providing end users with more bandwidth than they can possibly use, given the clogged state of the backbones.

The Internet is divided roughly into five layers.[17] **Figure 1.**

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[13] C. Bruno, *Building the Next Net*, Network World, Aug. 25, 1997, at 37.

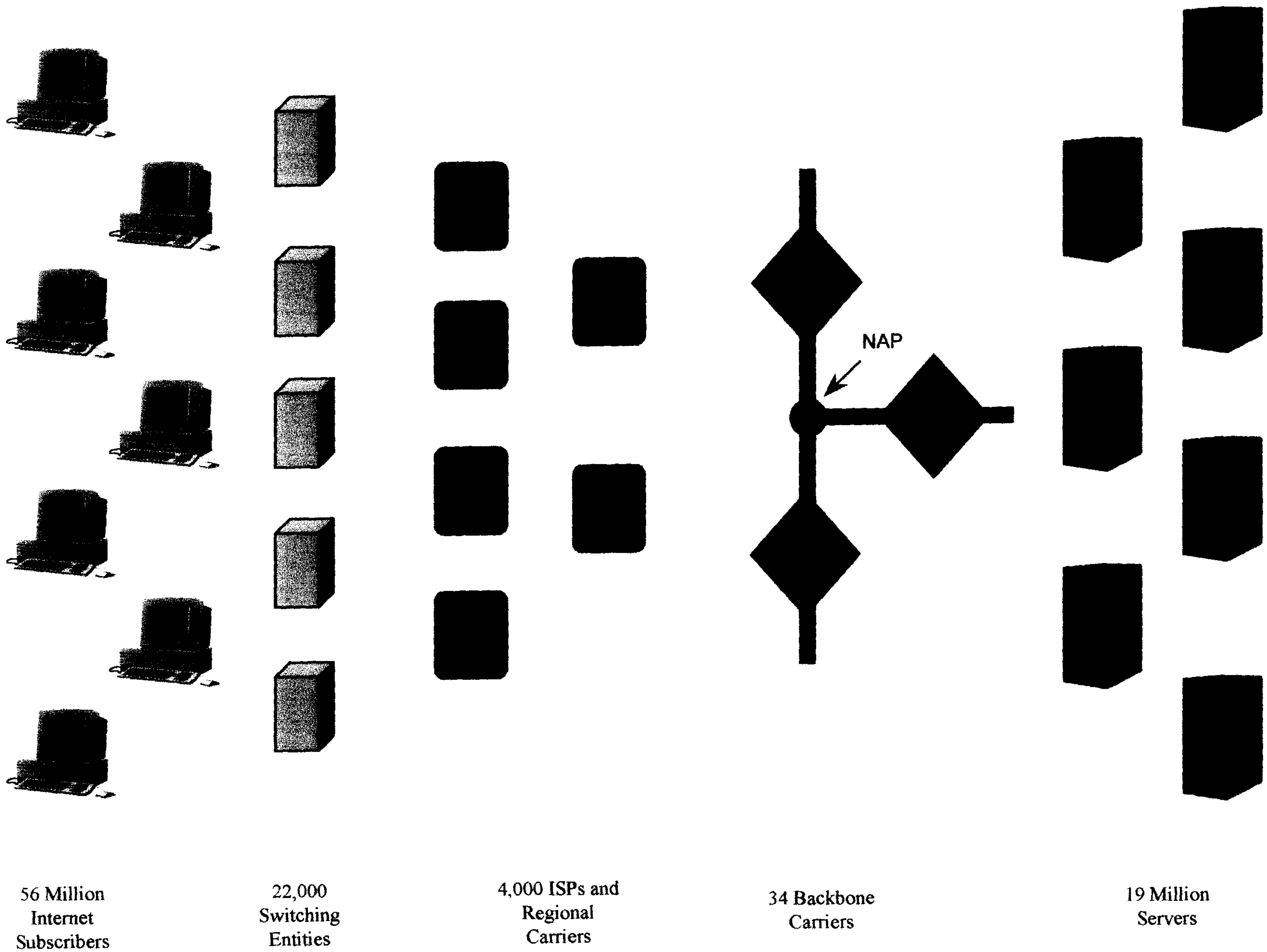
[14] "Congestion on the current Internet hampers its use in research, teaching, and learning," according to the University of Michigan. *Group Formed for Faster Internet*, AP Online, Oct. 8, 1997.

[15] A. Tisi, *Initiatives Hook into Net Dreams*, PC Week, Sept. 29, 1997, at 80.

[16] *See* J. Dvorak, *Breaking Up the Internet Logjam*, PC Magazine, Apr. 8, 1997, at 87.

[17] *See generally* J. Rickard, *Internet Architecture*, Boardwatch Magazine Directory of Internet Service Providers, July/Aug. 1997, at 6.

Figure 1: Internet Architecture



1. Some 56 million users – or more precisely, their computers, serial ports, modems, and ISDN adapters.

2. Local access, mostly supplied by local phone companies, through about 22,000 local switches nationwide.[18]

3. Over 4,000 Internet Service Providers (ISPs) that connect high-speed business lines and individual dial-up connections to Internet terminal equipment.[19]

4. Some 34 North American Internet backbone networks.[20] They interconnect at 11 major "network access points" (NAPs).[21]

5. Nineteen million servers, the computers on which content is stored and transactions are executed.

How fast an Internet subscriber can connect, or whether (s)he can connect at all, is determined by the slowest or busiest link or layer in this chain. The price of connection and service likewise depends on who is charging how much all the way up and down the line.

Most computers are linked to the Internet through an analog modem connected to a phone line. These wires were originally deployed to provide ordinary analog voice telephone service, which requires only 4 kHz of bandwidth, but they are quite capable of transmitting data – analog or digital – at much higher bandwidths. Copper wire used in typical telephone lines has a potential bandwidth of about 1 MHz.[22] Copper can sustain very high-speed data transmission, at

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[18] Bellcore, TR-EOP-000315, Local Exchange Routing Guide (LERG) (Dec. 1, 1997).

[19] J. Rickard, *Introduction*, Boardwatch Magazine Directory of Internet Service Providers, Fall 1997, at 4.

[20] J. Rickard, *Measuring the Internet*, Boardwatch Magazine Directory of Internet Service Providers, July/Aug. 1997, at 20.

[21] *Id.* at 8.

least over short distances. Various Digital Subscriber Line (xDSL) technologies currently under development, for example, can send data over existing copper wires at multi-megabit speeds.[23] **Figures 2 and 3.** How fast data can be transmitted over existing copper lines thus depends in large part on the quality of the modems or adapters connected at the two ends. Most users today have 28.8 or 33.6 kbps modems, although 56 kbps modems are available and are expected to be very popular in the near future.[24] **Figures 4 and 5.**

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[22] The Reohr Group, *ADSL: Turning Copper Into Gold* (1997), http://www.reohr.com/intelligence/papers/adsl2.html.

[23] DSL uses advanced electronics on either end of the line to upgrade ordinary copper wires to carry voice, data, and video, at very high speeds. A variety of types of DSL are under development, collectively referred to as xDSL.

[24] 54 percent of households connecting to the Internet use 28.8 or 33.6 kbps modems, 23 percent 56 kbps, and 15 percent 14.4 kbps or slower. The remainder of households (8 percent total) divide between various advanced technologies. Jupiter Communications Press Release, *56 Kbps "Midband" Solution Will Dominate Home Internet Access*, Oct. 17, 1996.

Figure 2: Present Capacity of Copper Loop

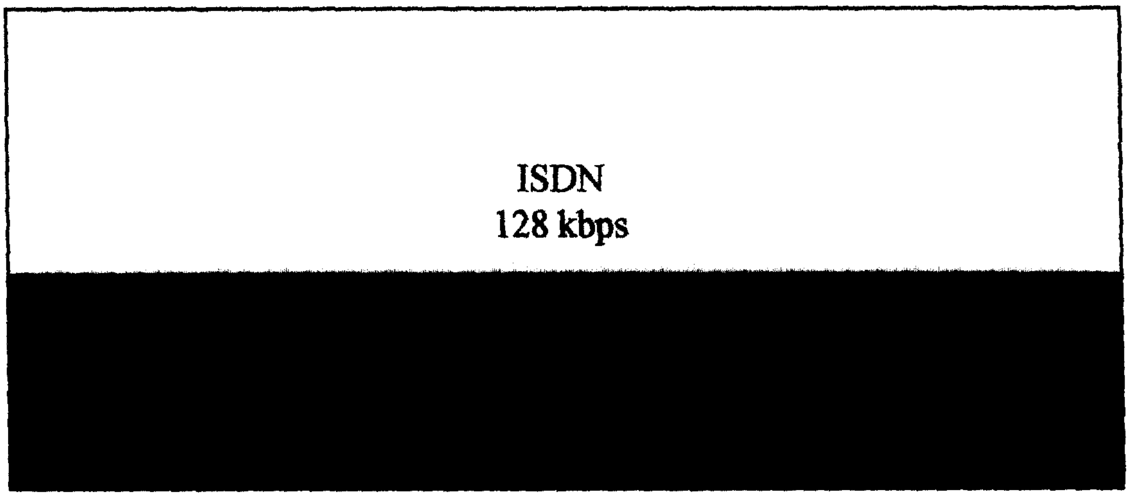


Figure 3: Future Capacity of Copper Loop (ADSL)

Figure 4: Evolution of Modem Speed

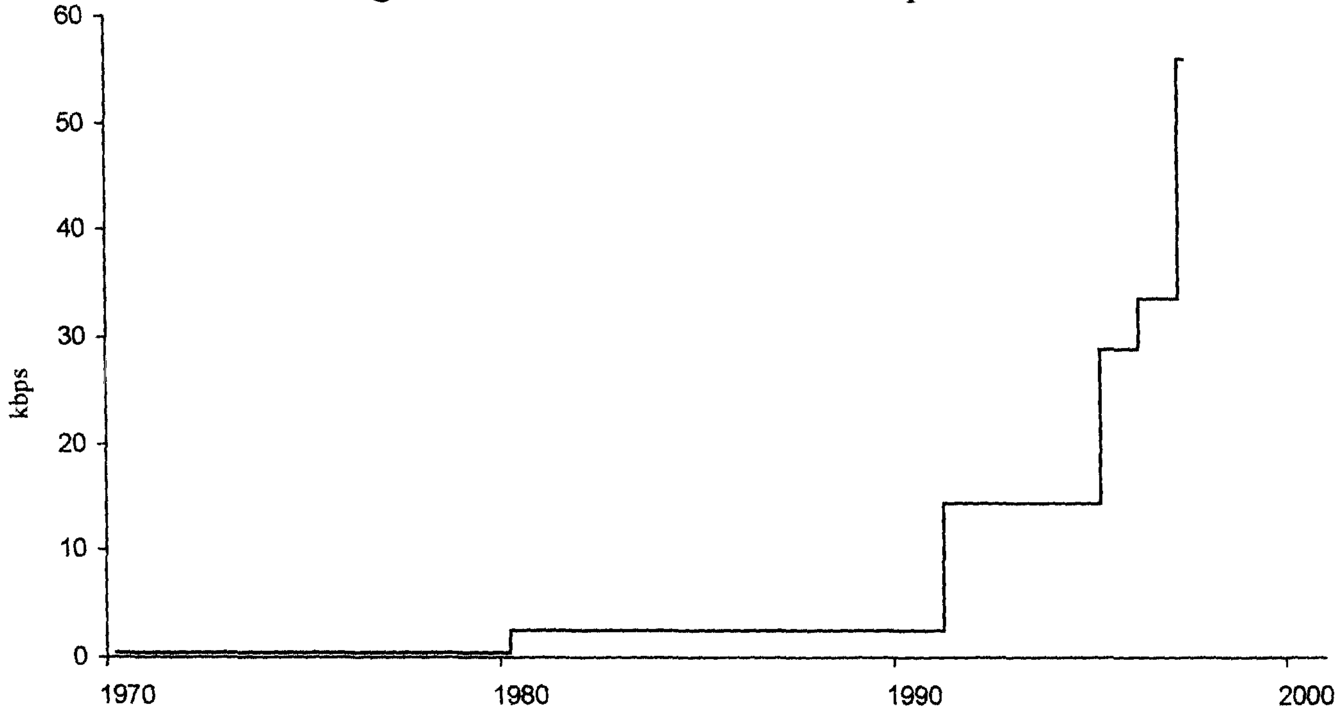
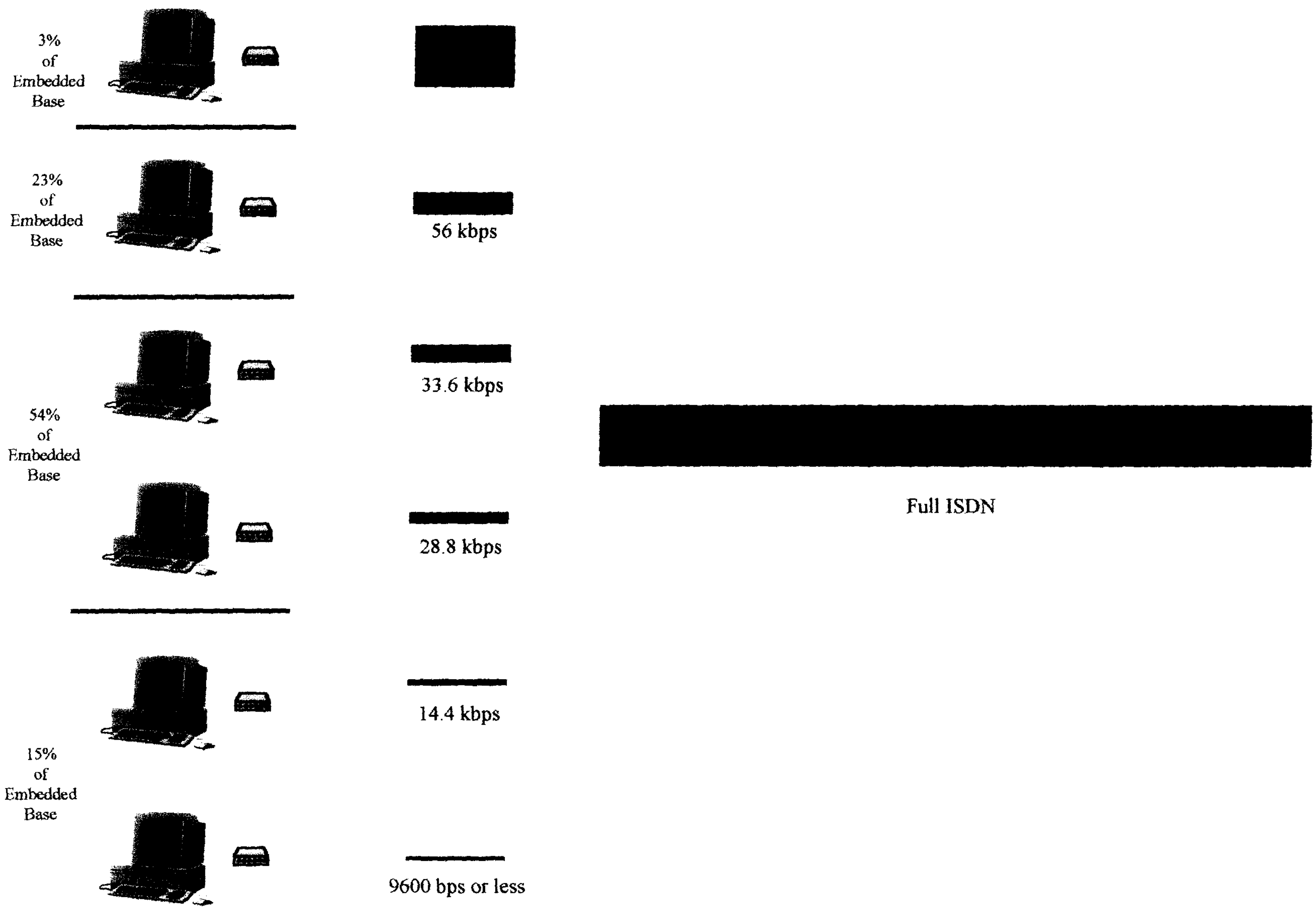


Figure 5: Maximum CPE Supported Bandwidth



Local phone companies already have upgraded most of their lines to ISDN – the Integrated Services Digital Network. ISDN supports digital connections at 128 kbps, three to five times faster than analog lines equipped with fast modems.[25] The new Bell Atlantic leads the nation in ISDN deployment: it now offers ISDN to almost 96 percent of its access lines.[26]

Figure 6.

The next generation digital technology is Digital Subscriber Line (xDSL). With appropriate regulatory relief, Bell Atlantic plans to deploy a variation of this technology -- asymmetric DSL, or ADSL -- that will offer speeds up to six megabits per second (Mbps) to its customers. ADSL offers a many-fold increase in bandwidth over ISDN; others offer well over 100 times the transmission speed.[27] ADSL can be used to serve 80 percent of U.S. telephone subscribers at reasonable cost.[28] Bell Atlantic has completed market trials in Northern Virginia,

[25] ISDN uses advanced electronics on either end of an ordinary copper wire to increase the bandwidth of the wire to two 64 kbps voice and data channels that can be bonded together to form one 128 kbps transmission path, together with one 16 kbps network signaling and data channel. Bellcore, SR-BDS-000828, A Guide to New Technologies and Services, Issue 7, at 4-7 (1993).

[26] FCC, Infrastructure of the Local Operating Companies Aggregated to the Holding Company Level at Tables 2(a) and 4(a) (1996).

[27] The various types of xDSL technologies vary by data rate and effective distance. ADSL provides 1.5 Mbps downstream and 16 kbps upstream at 18,000 feet; under optimal conditions (inside 9,000 feet on high quality lines), this improves to 9 Mbps down and 640 kbps up. High data rate Digital Subscriber Line (HDSL) uses two lines and achieves rates of 1.544 Mbps, equivalent to a T1 trunk. Single line DSL (SDSL) is similar to HDSL but uses only one line. SDSL can achieve the same throughput as HDSL with half the lines, but at shorter distances – 10,000 feet compared to 12,000 feet for HDSL. Very high data rate Digital Subscriber Line (VDSL) is used for the very shortest distances, and can achieve speeds of 13 Mbps under 4,000 feet and up to 52 Mbps at 1,000 feet. *See generally* ADSL Forum, *General Introduction to Copper Access Technologies*, http://www.adsl.com/general_tutorial.html. ADSL Forum, *ADSL Tutorial*, http://www.adsl.com/adsl_tutorial.html.

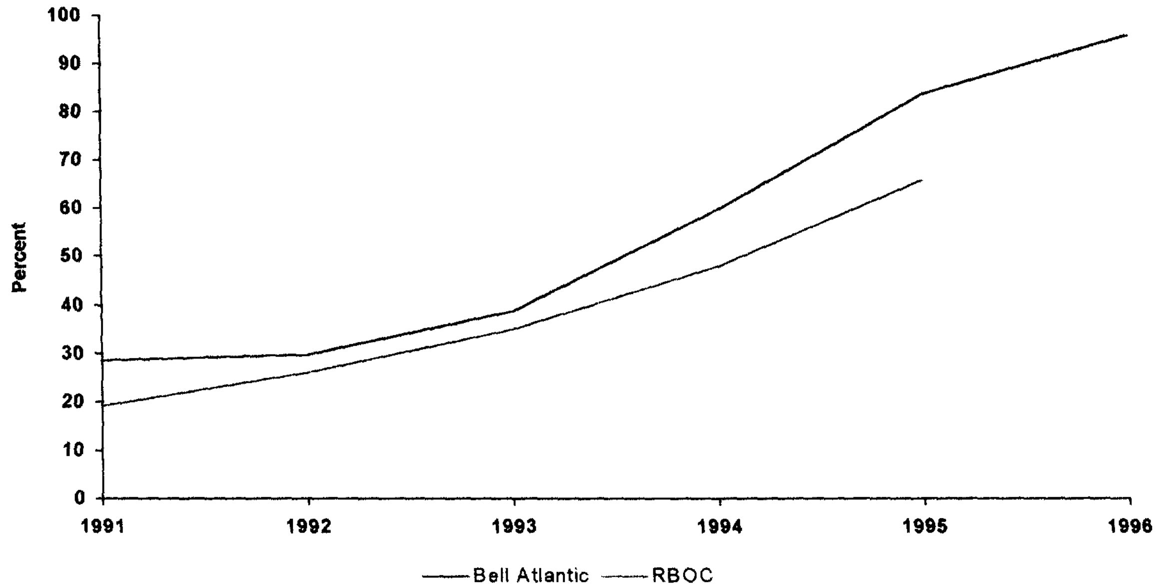
[28] The other 20 percent live more than 18,000 feet from their switch, beyond ADSL's maximum distance. *Id.*

and plans on rolling out commercial ADSL service to residential customers beginning in mid-1998.[29] Bell Atlantic is also looking to deploy other varieties of xDSL in the future.[30]

[29] Bell Atlantic Press Release, *Bell Atlantic to Offer ADSL-Based Service Starting in Mid-1998*, May 19, 1997.

[30] Bell Atlantic is considering deploying other DSL technologies, such as Very high data rate DSL (VDSL), which can transmit data at up to 52 Mbps over fairly short distances.

Figure 6: Deployment of ISDN



The Bell Companies have some of the right incentives to invest in these technologies. They allow the telephone companies to earn new revenue out of existing plant with only incremental costs. This helps them avoid deploying costly new transmission facilities.

Unlike the incumbent long-distance companies, local phone companies have much to gain by migrating data traffic off the existing voice network on to high-capacity, data-dedicated facilities. The growth of the Internet has caused some traffic congestion in certain Bell Atlantic switches, especially those located near major ISP points of presence.[31] While Bell Atlantic is quickly adding capacity to these switches to keep them running at 99.9 percent reliability, xDSL provides a more economical long-run solution. xDSL also allows telcos to isolate data traffic before it reaches the voice network and shunt it on to dedicated data facilities.[32]

Various regulatory policies, however, create strong disincentives to new investment in local Internet access facilities. Under the 1996 Act, Bell Companies are now required to "unbundle" and sell to their competitors whatever capabilities and services they offer over their networks,[33] at rates "based on the cost[s] of providing" them.[34] On new, risky investment in facilities and services that turn out to be very popular, Bell Companies can therefore hope to recover only their original costs. Former FCC Chairman Hundt has acknowledged that the unbundling rules, if applied to new services like ADSL, discourage innovation by Bell

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[31] P. Korzeniowksi, *Data Calls Jam Up Some CO Switches*, Internet Week, Oct. 6, 1997, at T19 (Bell Atlantic's Norfolk and Richmond central offices especially congested because they serve America Online's POPs).

[32] R. Gareiss, *Mapping a High-Speed Strategy*, Data Communications, Apr. 1997, at 62; A. Kay, *ADSL Deployment at the Starting Gate*, Internet Week, Oct. 6, 1997, at T23; ADSL Forum, *ADSL Tutorial*, http://www.adsl.com/adsl_tutorial.html.

[33] 47 U.S.C. § 251.

[34] 47 U.S.C. § 252(d).

Companies.[35] New, risky investments that fail, by contrast, are charged to Bell Company shareholders, through the vehicle of price-cap regulation.

Worse still, all Bell Company prices must be deflated according to a "productivity offset" or "X-factor" set by the FCC. The FCC's latest Price Cap Order sets the X-Factor at a level well in excess of what is "reasonable,"[36] thus threatening to choke off investment in new advanced services. Regulation alone may thus transform any well-engineered, efficiently-priced, new broadband service into a source of steadily growing loss in subsequent years. The more advanced the technology deployed, the greater the threat, because in such circumstances further technological advance is least likely to deliver instant, ongoing improvements in performance and declines in price that the Commission presumes into existence indefinitely into the future.

The new technology is at hand; the economic incentive to deploy it widely is not. If local phone companies introduce these services successfully, competitors will be able to buy them, at sharp discounts, and capture the profits. The Commission's preferred pricing standard for unbundled network elements requires local carriers to give competitors access to network elements at prices below even the incremental cost of providing them, and still further below the actual book cost including capital and depreciation. For just the same reason, competitors have little incentive to deploy the technology themselves. Why would they, when the FCC has

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[35] The Commission is also reportedly considering modifying its rules to exempt "innovative" services from the unbundling requirements. *See FCC Drafting Rule Proposal to Address ILECs' Innovation Concerns*, Communications Today, Sept. 17, 1997. The Alliance for Public Technology advised the FCC that incumbent LECs "have been given a disincentive to invest in advanced telecom facilities, which must be made available under the unbundling/wholesale resale scheme." Letter from Dr. Barbara O'Connor and Gerald E. Depo, Alliance for Public Technology, to Reed Hundt, Chairman, FCC, Aug. 4, 1997.

[36] The FCC set the X-factor at 6.5 percent, even though historical productivity gains (the measure the Commission admittedly considers most reliable) have never showed productivity gains even approaching 6.5 percent. *See* Fourth Report and Order at ¶¶ 137, 141, *Price Cap Performance Review for Local Exchange Carrier*,

directed that competitors may buy the existing network below cost, and successful new services at deeply discounted prices – with no need to face the risk of losing unsuccessful investments? Exempting Bell Atlantic's new technologies, such as xDSL, from the unbundling rules will, as former Chairman Hundt explains, "create economic incentives for the telephone companies that are proprietors of parts of the Internet, particularly the local loop, . . . to upgrade those particular businesses."[37]

Internet Service Providers. Over 4,000 ISPs connect users to the Internet itself. The ISPs receive incoming calls and connect them to Internet routers, from which they are connected to the "backbones" that carry Internet traffic across the U.S. and the world. Smaller ISPs just link up with larger ones, but the regional and national ISPs link directly to the national backbones. The largest ISPs include America Online, CompuServe, Microsoft Network, AT&T, and WorldCom's UUNet division. Bell Atlantic and several other Bell Companies are also ISPs.

Local phone lines can deliver data much faster than the ISPs can receive it. Only 36 percent of ISPs even claim to support 56 kbps connections;[38] the largest ISPs are only in trials of the technology.[39] Access speeds in this industry often run far ahead of reality. For example, many ISPs advertise support for 28.8 kbps modems but actually deliver 20 kbps or less. And

CC Dkt. No. 94-1 (F.C.C. May 21, 1997).

[37] *FCC Drafting Rule Proposal to Address ILECs' Innovation Concerns*, Communications Today, Sept. 17, 1997.

[38] Some 1,579 ISPs offer some form of 56 kbps connection. J. Rickard, *Introduction*, Boardwatch Magazine Directory of Internet Service Providers, Fall 1997, at 4.

[39] *See Does Your ISP Offer 56K?*, PC Magazine, Oct. 21, 1997, at 113 (AOL, MSN, and Prodigy trialing 56 kbps modems in several large markets; Netcom offers access for an additional $5-10 per month).

because the modem industry has yet to settle on a 56 kbps modem standard, customers will get at best 33.6 kbps connections if they do not select the same 56 kbps modem as their ISP.[40]

Even fewer ISPs support full, 128 kbps ISDN connections. Some that claim to offer ISDN links in fact will bond only a single ISDN channel (64 kbps).[41] Well under half of current Internet subscribers are served by an ISP that offers full, dual-channel ISDN. Only 17 percent of the subscribers served by the top ten ISPs can make full use of the ISDN service that Bell Atlantic offers to 98 percent of its subscribers.[42] **Figure 7.** The few ISPs that support ISDN access of any kind charge stiff premiums for doing so. AOL charges an additional $49.95 a month for single-channel ISDN access. Microsoft charges the same premium for dual-channel support. MCI, which offers ISDN only to business customers, charges $9.95 for the first hour and $2.50 for each additional hour. **Figure 8.**

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[40] R. Pacchinano, *Modems Take Route 56*, Computer Shopper, June, 1997 at 574. One ISP head explained that "[i]t's not worth investing in the upgrades and the modems if you don't know which standard will be chosen." M. Graser, *Speed Bump*, Arizona Republic, July 14, 1997, at E1.

[41] As one observer explains, "[m]any Internet service providers are discovering a problem with their access equipment that prevents the pairing or bonding of a caller's two 64-Kbps B channels into a single 128-Kbps pipe. . . . The problem isn't unique to any one vendor's products. Indeed, it has affected the entire industry and has become particularly acute as the concentration of ISDN users in any one provider's service region has reached a critical mass." J. Rendleman and K. Gerwig, *Grappling With Remote Access – ISDN Falls Short of 128K to ?Net*, Communications Week, July 7, 1997.

[42] ISDN capability determined by reviewing ISPs' listings in the The List's ISP directory (http://thelist.internet.com), Boardwatch Magazine's Directory of Internet Service Providers, July/Aug. 1997, and the ISPs' respective web sites.

Figure 7: Maximum ISP Supported Bandwidth

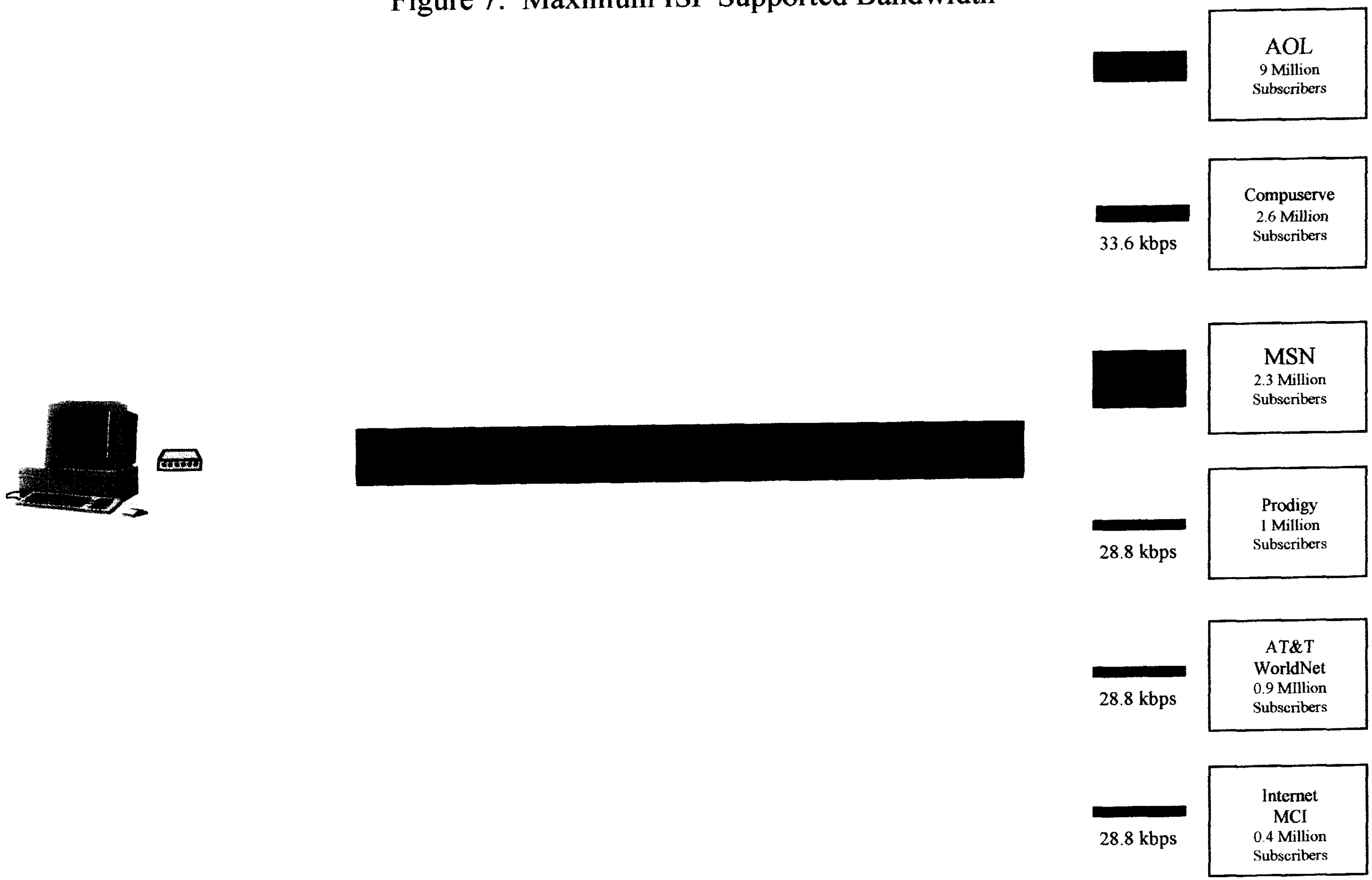
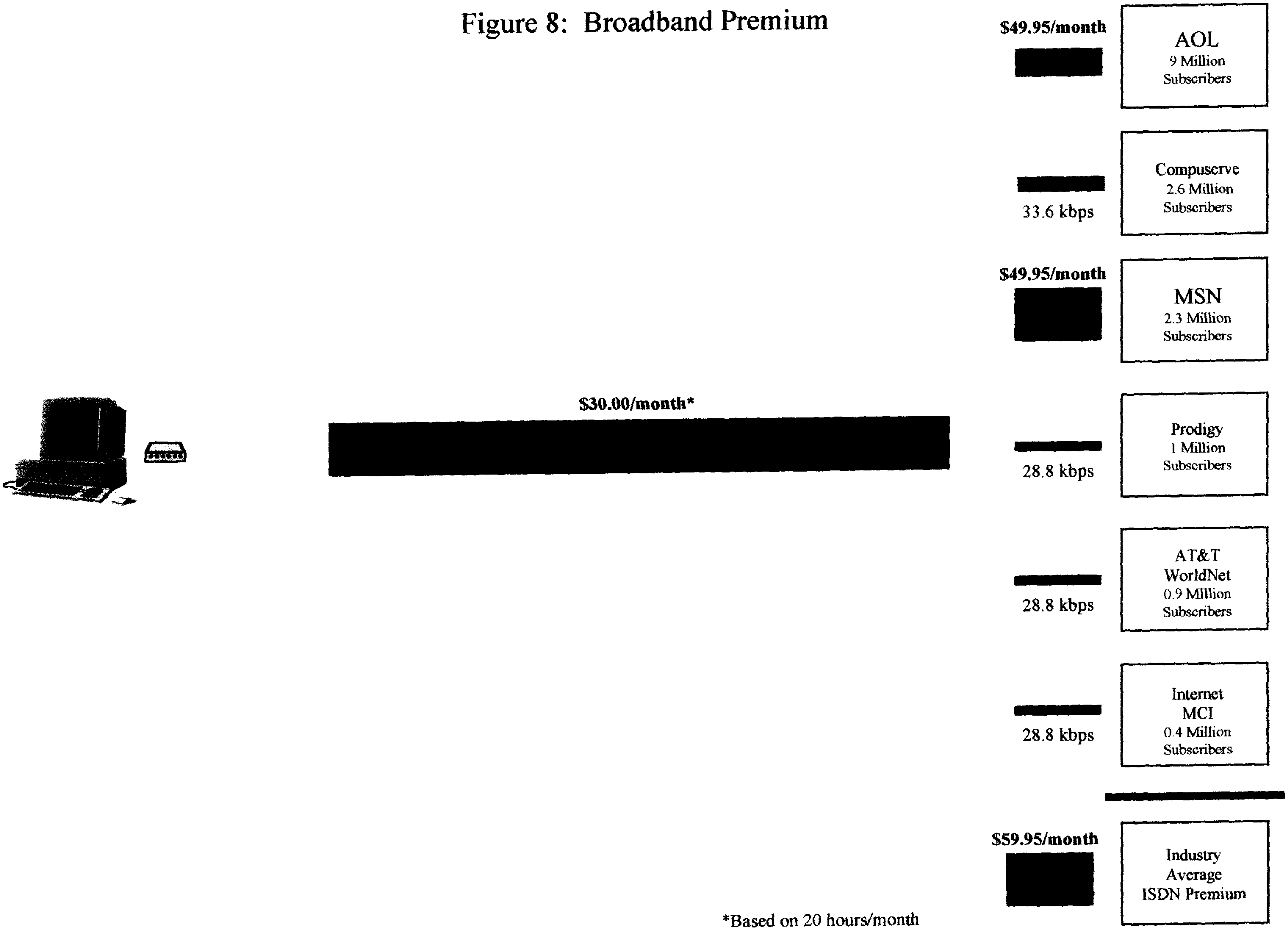


Figure 8: Broadband Premium



*Based on 20 hours/month

The outlook for Digital Subscriber Line (DSL) technologies is much the same – local phone companies will offer more bandwidth, sooner and cheaper, than the ISPs to which these high-speed links connect. Bell Atlantic and several other local carriers are at least conducting Internet access trials using ADSL; Ameritech, US West, GTE, and SBC are offering commercial service in limited locations.[43] MSN is participating in a trial of ADSL with GTE, but only a few other, much smaller ISPs offer ADSL connections.[44]

National Backbones. Internet service providers hand their traffic off to some 34 North American Internet backbone networks. Backbone providers install fast routers in a number of cities, and then lease high-speed data lines to link the routers.[45] These backbone links are typically 45 Mbps T-3 leased lines, although some backbone providers have installed or are planning to install 155 Mbps OC-3 or 622 Mbps OC-12 links between certain cities.[46] The backbone providers will then typically extend their backbones down to the regional level by placing points of presence in surrounding communities and leasing 1.544 Mbps T-1 lines or 56 kbps lines to connect to the main routers.[47] Even though the absolute speeds of these backbones are quite fast, they are also highly shared, with multiple users vying for bandwidth. The 34 backbones interconnect at 11 main network access points (NAPs) located throughout the U.S.

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[43] *See* ADSL Forum, *ADSL Trials and Service Deployments* (1997), http://www.adsl.com/trial_matrix.html.

[44] *Id.*

[45] J. Rickard, *Measuring the Internet*, Boardwatch Magazine Directory of Internet Service Providers, July/Aug. 1997, at 14.

[46] MCI spent $60 million in 1996 upgrading to OC-12. J. Rickard, *National Backbone Operators*, Boardwatch Magazine Directory of Internet Service Providers, July/Aug. 1997, at 156. TCG CERFnet, owned by Teleport, has OC-3 connections running on its major East Coast-West Coast connections and through the Boston-Washington corridor. *Id.* at 192. WorldCom/UUNet is upgrading its backbone to OC-12 connections. *Id.* at 198.

[47] J. Rickard, *Measuring the Internet*, Boardwatch Magazine Directory of Internet Service Providers, July/Aug. 1997, at 14.

Keynote Systems and Boardwatch Magazine conducted a major study of the performance of the Internet backbones, demonstrating that they are congested, and getting worse. The study was conducted in 30 U.S. cities and compiled over 3.6 million data points based on download attempts performed by users with T-1 or faster access around the clock for a six-week period.[48] The results showed that, on average, users cannot download from the Internet faster than at about 40 kilobits per second – significantly slower than a 56 kbps modem, less than a third the top speed of full ISDN (128 kbps), and slower still than forecasted speeds for ADSL (6 Mbps), or cable modems (10 Mbps) – regardless of the speed of their originating connection. The nationwide average speed was about 5 percent slower than in a similar study conducted four months earlier.[49] Download speeds were significantly slower when users connected during popular business or evening hours, or for users connecting in more congested parts of the country.[50] The study concluded that "most of their performance problems occur out in the Internet's infrastructure somewhere between the web site and its users: at the NAPs (Network Access Points) where backbone providers interconnect, in one or more routers along the communication path, or in a DNS (Domain Name Service) close to the user."[51]

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[48] Keynote Press Release, *Keynote Systems Clocks True Speed On The Internet Highway At 5,000 Characters Per Second, or Only 40 Kbps*, Oct. 21, 1997.

[49] Keynote Systems and Boardwatch Magazine, *Keynote/Boardwatch Internet Backbone Index*, Nov. 11, 1997, http://www.keynote.com/measures/backbones/backbones.html.

[50] *Id.* Jim Barrick, President and CEO of Keynote, noted that, "Most Web users will actually experience performance worse than the measured average. That's because our measurements were conducted over faster connections than most users have available and included measurements performed at night when traffic was light." Keynote measured Internet speed using T-1 or T-3 connections only one or two router "hops" from the backbones themselves; residential users will likely not have such fast or close connections. *Id.*

[51] Keynote Systems, *Top 10 Discoveries About the Internet*, http://www.keynote.com/measures/top10.html.